

App. No 10/058,541
Amdt. Dated August 19, 2004
Reply to Office Action of May 25, 2004

REMARKS/ARGUMENTS

Claim 14 has been amended. Claims 1 – 12, 14, and 15 are pending in the application.

In the Office Action, claims 1 – 12, 14, and 15 are rejected under 35 U.S.C 103(a) as being unpatentable over US Patent No. 3,653,833 to Watson et al taken with US Patent No. 4,044,098 to Miller et al.

Applicants respectfully traverse the rejections of claims 1 – 12, 14, and 15 in view of the following comments.

Claim 1 of the present application recites a method of removing metallic mercury and ionic mercury from flue gases. The inventive method includes the steps of conveying a gas that contains sulfur dioxide, or other adequate amounts of sulfur in the form of H_2S or COS , and a gas that contains hydrogen, to a catalyzer for producing a gas G that contains elemental sulfur and hydrogen sulfide and conveying the gas G to flue gas upstream of a separator, wherein mercury in the flue gas reacts with elemental sulfur and ionic sulfur in the gas G and is separated out in the separator.

In the Office Action, it is asserted that Watson et al '833 teaches a method for the conversion of sulfur dioxide (SO_2) into a mixture of hydrogen sulfide (H_2S) and elemental sulfur (S), wherein the method comprises heating the gas mixture of sulfur dioxide and a reducing gas to a reaction temperature of about 1,000 to 2,400° F, reacting the heated mixture in the presence of a catalyst, and recovering heat from the product gas stream, thereby lowering the temperature of the stream to about 700 to

App. No 10/058,541
Amdt. Dated August 19, 2004
Reply to Office Action of May 25, 2004

800° F. The sulfur dioxide gas may be essentially pure or it may comprise only a small percent of a gas mixture, such as in an industrial waste gas. The reducing gas may contain at least one of carbon monoxide, hydrogen, or any gaseous hydrocarbons, such as methane, ethane, or natural gas. The Office Action notes that Watson et al '833 does not teach possible uses for the product gas comprising hydrogen sulfide and elemental sulfur.

The Office Action further notes that Miller et al '098 teach the removal of mercury from a natural gas stream by reacting the stream with an amount of hydrogen sulfide sufficient to cause precipitation of mercury as mercury sulfides. The sulfides of mercury are then scrubbed from the natural gas stream and further removed by a filter. Thus, it is asserted in the Office Action, it would have been obvious to use the hydrogen sulfide containing gas of Watson et al '833 as the hydrogen sulfide source of Miller et al '098 because it is obvious to use the product of one process as a reactant in another process if they are similar materials and the "other process" requires the product of the first product. Moreover, the Office Action asserts, with regard to the reaction of the elemental sulfur with mercury to form mercury sulfide, that it is inherent that this reaction occurs, as is known in the art.

Watson et al '833 discloses a reaction chamber 28 containing a suitable catalytic material for catalytically reducing sulfur dioxide gas (SO_2) to elemental sulfur with the by-products of such reduction comprising hydrogen sulfide and elemental sulfur.

Miller et al '098 discloses a process for treating a natural gas stream containing

App. No 10/058,541
Amdt. Dated August 19, 2004
Reply to Office Action of May 25, 2004

mercury to produce natural gas with a reduced mercury content. The process of Miller et al '098 entails contacting the mercury-containing natural gas stream with an amount of hydrogen sulfide sufficient to cause precipitation of mercury as mercury sulfides and further entails the contacting of the natural gas stream in the presence of the hydrogen sulfide with an amine that will absorb hydrogen sulfide to absorb hydrogen sulfide in excess of the mercury precipitating amount.

Applicants agree with the statement in the Office Action that a hydrogen sulfide containing gas such as that produced in the Watson et al '833 process could serve as the hydrogen sulfide source for the Miller et al '098 process for treating a natural gas stream containing mercury to produce natural gas with a reduced mercury content. However, hydrogen sulfide removes ionic mercury (Hg^{+2}) but does not remove metallic mercury (Hg^0). To this extent, while the natural gas treated by the Miller et al '098 process may be suitably conditioned by the removal of ionic mercury (Hg^{+2}) therefrom, the flue gas treated by the method of the present invention comprises both metallic mercury (Hg^0) and ionic mercury (Hg^{+2}) which must be removed. Thus, even if it were to be granted that the Watson et al '833 process could serve as the hydrogen sulfide source for the Miller et al '098 process, there is no teaching or disclosure in Watson et al '833 or Miller et al '098 concerning the removal from a flue gas of not only ionic mercury (Hg^{+2}) but metallic mercury (Hg^0) as well.

With regard initially to the absence in Miller et al '098 of any suggestions concerning the removal of metallic mercury (Hg^0), Applicants note that Miller et al '098

App. No 10/058,541
Amdt. Dated August 19, 2004
Reply to Office Action of May 25, 2004

makes no mention of a removal approach for removing metallic mercury (Hg^0). Instead, to the extent that Miller et al '098 mentions the removal of mercury from natural gas, Miller et al '098 discloses the removal of mercury from natural gas by introducing hydrogen sulfide into the natural gas so as to precipitate sulfides of mercury. The complete absence of any discussion in Miller et al '098 of a method for removing metallic mercury (Hg^0), let alone the complete absence of any discussion in Miller et al '098 of the need to remove metallic mercury (Hg^0), indicates that Miller et al '098 assumes either that there is no metallic mercury (Hg^0) in the natural gas to be treated by its method or that the presence of metallic mercury (Hg^0) in the natural gas is so negligible as to not require any removal at all.

Given the complete indifference of Miller et al '098 to removal of metallic mercury (Hg^0), it is submitted that one of ordinary skill in the art would find no motivation in Miller et al '098 to consider modifying the Miller et al '098 process to additionally include steps to remove metallic mercury (Hg^0) from the natural gas to be treated. Accordingly, while one of ordinary skill in the art may, in performing the Miller et al '098 ionic mercury (Hg^{+2}) removal process, turn to any suitable hydrogen sulfide source (including the Watson et al '833 process), there is no motivation for one of ordinary skill in the art to even consider the Watson et al '833 process or, in fact, any other process, as a source of a metallic mercury (Hg^0) removal agent.

It is for this reason, Applicants submit, that no argument can be made that one of ordinary skill in the art would turn to the Watson et al '833 process not only as a source

App. No 10/058,541
Amdt. Dated August 19, 2004
Reply to Office Action of May 25, 2004

of hydrogen sulfide but, as well, would turn to the Watson et al '833 process as a source of a metallic mercury (Hg^0) removal agent (specifically, as a source of elemental sulfur). Moreover, when, on the one hand, it is recognized that Miller et al '098 evinces no interest with respect to the removal of metallic mercury (Hg^0) and, on the other hand, it is recognized that the Watson et al '833 process produces several by-products in addition to hydrogen sulfide and elemental sulfur, including, for example, carbon dioxide, water, carbon monoxide, and carbon disulfide, it can be seen that the sole motivation for one of ordinary skill in the art to selectively incorporate only the hydrogen sulfide and elemental sulfur by-products of the Watson et al '833 process into the Miller et al '098 process could only come from the present application and such hindsight reconstruction of the inventive method is improper.

Additionally, Miller et al '098 itself would discourage one of ordinary skill in the art from attempting to introduce into the Miller et al '098 process not only the hydrogen sulfide produced by the Watson et al '833 process but, as well, the elemental sulfur produced by the Watson et al '833 process. The Miller et al '098 process comprises the steps of introducing more than the stoichiometric amount of hydrogen sulfide into the natural gas to be treated and thereafter contacting the natural gas and hydrogen sulfide mixture with a liquid amine to absorb the excess hydrogen sulfide. Thus, even if one of ordinary skill in the art, in performing the Miller et al '098 process, were to contemplate introducing, as well, elemental sulfur into the natural gas to be treated, the particular approach disclosed in Miller et al '098 with respect to hydrogen sulfide of introducing

App. No 10/058,541
Amdt. Dated August 19, 2004
Reply to Office Action of May 25, 2004

more than a stoichiometric amount thereof and then, further, introducing an absorption agent (i.e., a liquid amine) for the excess hydrogen sulfide amount makes it clear that Miller et al '098 itself, if it had given any consideration to introducing another treatment agent such as, for example, elemental sulfur, would have taken into account the chemical reactions and supply logistics for such an additional introduction, including, among other considerations, the desirability of adding more than a stoichiometric amount of elemental sulfur, the temperature and kinetic conditions for such treatment, and various other considerations. The fact that Miller et al '098 does not in the least mention any such considerations for introducing elemental sulfur is clear evidence that Miller et al '098 does not contemplate the introduction of elemental sulfur into its mixture.

Claim 14 as currently amended recites a method of removing metallic mercury and ionic mercury from flue gases, the method including steps of combusting a combustible composition as a consequence of which flue gases comprising both metallic mercury and ionic mercury are created and flowing the flue gases along a flow path such that the flue gases flow past a location upstream of a separator, through the separator, and then past a location downstream of the separator. Additionally, claim 14 as currently amended recites diverting, at the location downstream of the separator, a partial stream of the flue gas that contains sulfur dioxide or other adequate amounts of sulfur in the form of H_2S or COS and conducting the partial stream of the flue gas to a catalyzer. The method recited in claim 14 as currently amended also includes the step

App. No 10/058,541
Amdt. Dated August 19, 2004
Reply to Office Action of May 25, 2004

of conveying a gas that contains hydrogen to the catalyzer whereat the sulfur dioxide or other adequate amounts of sulfur in the form of H_2S or COS in the partial stream of the flue gas conducted to the catalyzer reacts with hydrogen to produce a gas G that contains elemental sulfur and hydrogen sulfide. Lastly, the method recited in claim 14 as currently amended includes conveying the gas G containing elemental sulfur and hydrogen sulfide to the location upstream of the separator for contact with the flue gas thereat, wherein metallic mercury and ionic mercury in the flue gas react, respectively, with elemental sulfur and hydrogen sulfide in the gas G and are separated out in the separator as the flue gases thereafter flow through the separator.

Applicants submit that the amine scrubber operation of the Miller et al '098 arrangement would not provide any motivation for one of skill in the art to remove metallic mercury and ionic mercury from flue gases in accordance with claim 14 as currently amended, wherein, in accordance with this inventive method, a partial stream of the flue gas that contains sulfur dioxide or other adequate amounts of sulfur in the form of H_2S or COS is diverted to a catalyzer to produce thereat a gas G containing elemental sulfur and hydrogen sulfide. The inventive method recited in claim 14 as currently amended takes advantage of the fact that combusting a combustible composition results in a flue gases that contains sulfur dioxide or other adequate amounts of sulfur in the form of H_2S or COS , whereupon this sulfur dioxide or other adequate amounts of sulfur in the form of H_2S or COS in the partial stream of the flue gas catalyzer reacts with hydrogen at the catalyzer to produce a gas G containing

App. No 10/058,541
Amdt. Dated August 19, 2004
Reply to Office Action of May 25, 2004

elemental sulfur and hydrogen sulfide. Miller et al '098 contains no hint or suggestion that its mercury-containing stream to be treated (i.e., the natural gas stream) is to be partially diverted so that some constituent of the natural gas stream can be reacted with another substance so as to form the hydrogen sulfide that Miller et al '098 deploys for removing ionic mercury (Hg^{+2}) from the natural gas stream. In contrast, the method recited in claim 14 as currently amended in fact takes advantage of the presence of certain constituents (i.e., sulfur dioxide or other adequate amounts of sulfur in the form of H_2S or COS) in the mercury-containing stream to be treated (i.e., the flue gas) to create its mercury removal gas G.

Accordingly, it is submitted that the method of the present invention as recited in claim 1 is neither taught nor suggested by the prior art of record and, additionally, it is submitted that claims 2 - 12, which each ultimately depend from claim 1, and claims 14 and 15 are also neither taught nor suggested by the prior art of record for at least the reasons as set forth with respect to claim 1. Reconsideration of the rejections of claims 1 - 12, 14, and 15 under 35 USC Section 103(a) is therefore respectfully requested.

Applicants submit that claims 1 - 12, 14, and 15 are now in condition for allowance and early action toward that end is respectfully requested. However, should the Examiner have any further comments or suggestions, the undersigned would very

App. No 10/058,541
Amdt. Dated August 19, 2004
Reply to Office Action of May 25, 2004

much welcome a telephone call from him in order to resolve any outstanding issues and expedite placement of the application into condition for allowance.

Respectfully Submitted,



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